

# Flow Directed-Pulmonary Artery Catheterization in Surgical Patients:

## Indications and Modifications of Technic

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**D**IRECT ASSESSMENT of left atrial pressure is most desirable in critically ill patients and with the advent of the flow directed pulmonary artery catheter described by Swan, Ganz *et al*,<sup>19</sup> this measurement can be conveniently and repeatedly obtained. Forrester<sup>10</sup> has reported the usefulness of such information in caring for patients with myocardial infarction. The usefulness of left atrial pressure measurements in cardiac surgical patients is well documented.<sup>11,17</sup> We have passed over 120 of these catheters in the last eight months in general (non cardiac) surgical patients. As our experience with the catheter has mounted, alterations of technic and additional applications have evolved. We wish to present certain changes in technic we have found to be helpful in positioning and maintaining the catheter, in avoiding complications and to present our indications for its use in surgical patients.

### Method

The technic initially described advocated placement of the catheter via a surgically exposed antecubital vein. Preferentially, we have adopted percutaneous placement via the right internal jugular vein. A #22 gauge spinal needle with a 2 cc. syringe attached is threaded through a thin wall 2" 12 gauge needle (Fig. 1). The spinal needle is then advanced through the

lateral part of the sternocleidomastoid muscle belly until its entrance into the internal jugular vein is confirmed by aspiration of blood. The 12-gauge needle is then advanced using the spinal needle as a guide. The inner needle is then removed and correct positioning of the larger needle is confirmed by aspiration. The catheter is then introduced and advanced into the pulmonary artery as previously described. The needle is then withdrawn from the vein and the catheter fixed to the skin with a simple suture. We use an organic iodide ointment and occlusive sterile dressing at the skin puncture site.

In some patients it has been desirable to position the tip of the catheter preferentially in one lung. In these instances, when the catheter has been advanced into the right ventricle, the patient is turned to a lateral position with the desired side positioned superiorly. When the balloon is inflated and the catheter is advanced into the pulmonary artery, it most often floats upward into the desired side. Confirmation of catheter position is obtained by portable chest x-ray in these cases only.

### Discussion

We feel that the technic described has certain advantages in surgical patients. We had experienced difficulty in traversing the angle of the shoulder using both central venous pressure catheters as well as

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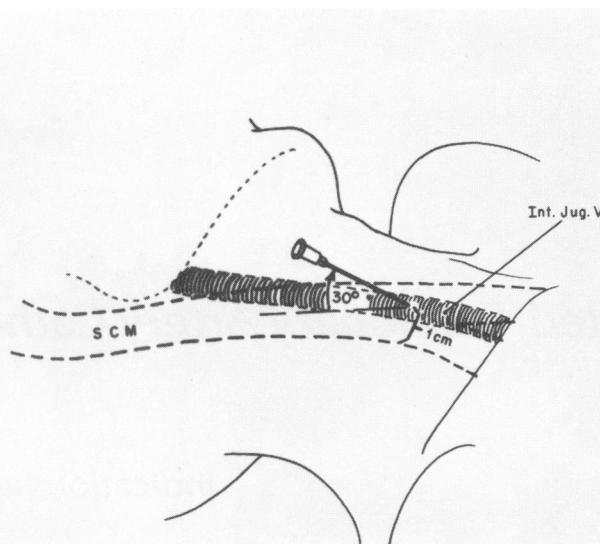
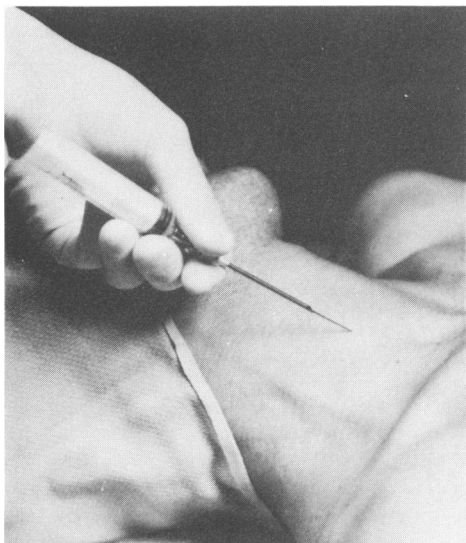


FIG. 1. Percutaneous puncture of the internal jugular vein. Note #22 gauge spinal needle threaded through standard #12 gauge needle to locate vein. Point for needle introduction is 3-finger breadths above clavicle, one centimeter within the lateral border of the sternocleidomastoid muscle. Needle is aligned parallel to the anterior border of the muscle and directed posteriorly at a 30° angle.

Swan-Ganz catheters. Therefore, the right internal jugular vein was selected as the shortest and most direct route to the right atrium. We also found that wedge tracings could not easily be maintained when the catheter had been positioned through a peripheral vein in surgical patients in whom motion must be encouraged. The decreased catheter motion and shorter length of catheter *in situ* obtained using the internal jugular route has practically eliminated this problem. At the present time, passage to the wedge position has been difficult only in patients with low cardiac outputs. When possible, augmentation of the cardiac output has been followed by successful passage of the catheter in some of these patients. Experience with long-term venous cannulation for hyperalimentation suggested that direct introduction of a catheter into a high flow, large bore vein decreased septic and thrombotic complications.<sup>8</sup> These considerations also led to selection of the internal jugular vein since anticoagulation, as recommended<sup>9</sup> would not be possible in the intra- and immediate postoperative period.

The use of the #22 spinal needle guide is especially valuable in a teaching institution, since the potential hazard of the 12-gauge hole in the carotid artery would seem to be significantly greater than a #22-gauge hole. This technic has been successfully used for positioning standard central venous pressure catheters as well.<sup>6</sup>

Rapidity and ease of insertion, greater patient acceptability, simplification of equipment and technic result in the entire procedure resembling simple venipuncture, rather than a formal heart catheterization. Catheter patency has been maintained by a constant infusion pump since intermittent injections have not proved satisfactory in our hands. Repeated evaluation

of the character of the tracing has also been important, since loss of the characteristic pulmonary artery tracing suggests that the tip of the catheter has advanced peripherally and totally occluded a pulmonary artery segment. Pulmonary infarction has already been documented as a result.<sup>4</sup> Repositioning of the catheter in place for longer than 24 hours beyond simply withdrawing a short segment has not been attempted for fear of increasing the risk of catheter induced sepsis.

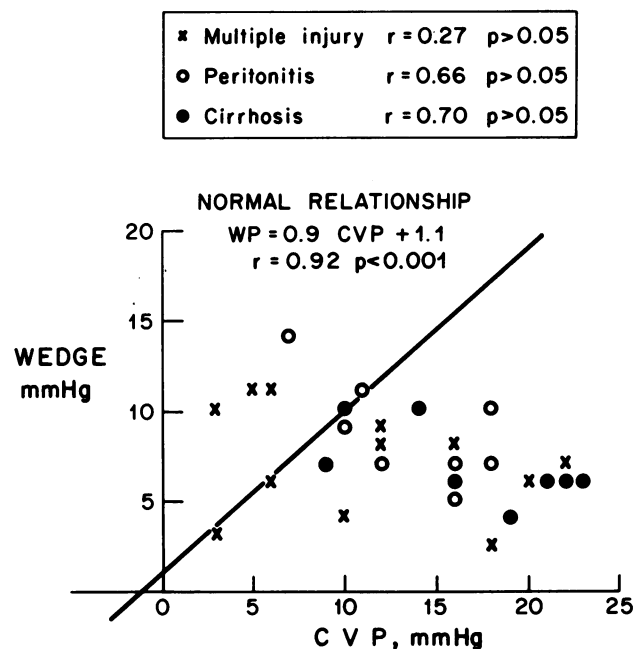


FIG. 2. Relationship of CVP and WP in normal, severe multisystem injury, decompensated cirrhosis and peritonitis. Note regression line indicating normal relationship between CVP and WP.  $p < 0.001$  indicates significant relationship. Relationship for values obtained in these three disease states was not significant. Wide scattering of points is evident.

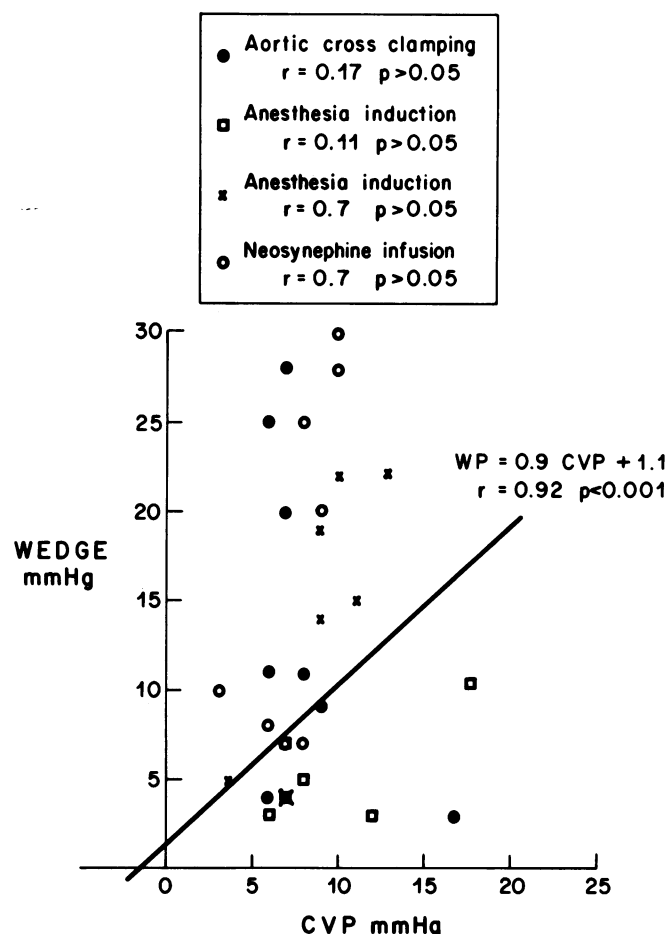


FIG. 3. CVP and WP comparison of normal with abnormal relationship. Normal relationship indicated by regression line. Each patient is represented by a separate symbol. Multiple observations over 2-hour period are plotted. Note complete unpredictability of WP from corresponding CVP.  $P$  was greater than 0.05 in each instance. 30 mm. Hg variation in WP while CVP remained essentially unchanged have been common.

Intracardiac knotting of the catheter has been reported.<sup>15</sup> If no more than 10 cm. of the catheter is introduced while the catheter remains in either the right atrium or right ventricle, this complication can be successfully avoided.

In addition to patients with acute myocardial infarction or undergoing cardiac surgery, there are additional situations in which knowledge of the pulmonary artery pressure, pulmonary capillary wedge pressure and sampling of true mixed venous blood are desirable. We have found that central venous pressure does not accurately reflect left atrial pressure in patients with decompensated cirrhosis, advanced peritonitis, and multisystem trauma<sup>7</sup> (Fig. 2). Right ventricular function in these three groups is compromised at a time when left ventricular function may be preserved. Elevation of central venous pressure in these patients may, therefore, reflect right ventricular fail-

ure, not hypervolemia. Knowledge of the wedge pressure in these instances permits the functional evaluation of each ventricle independently.

In patients with coronary artery disease, impaired left ventricular reserve may be present.<sup>3</sup> The stress of major operation in such situations may well precipitate left ventricular failure. We have found central venous pressure to be an unreliable guide to left atrial pressure in such patients (Fig. 3). Efforts to identify early left ventricular failure are desirable, since the decrease in coronary flow induced by overt failure can produce additional systemic complications, such as frank myocardial infarction, mesenteric infarction and acute tubular necrosis.<sup>13</sup>

Assessment of left atrial pressure is desirable in any patient in whom massive transfusion may be required. While central venous pressure and wedge pressure may change in a similar fashion in normal patients in response to volume infusions (Fig. 4), identification of this normal response unfortunately is only retrospective.

Non-cardiogenic pulmonary edema as an entity appears to be more frequent than we would have suspected. Demonstration of a low wedge pressure in the face of clinical and x-ray evidence of pulmonary edema will direct diagnosis and therapy toward other possible etiologic agents including transfusion reactions, unsuspected aspiration and allergic drug reactions.

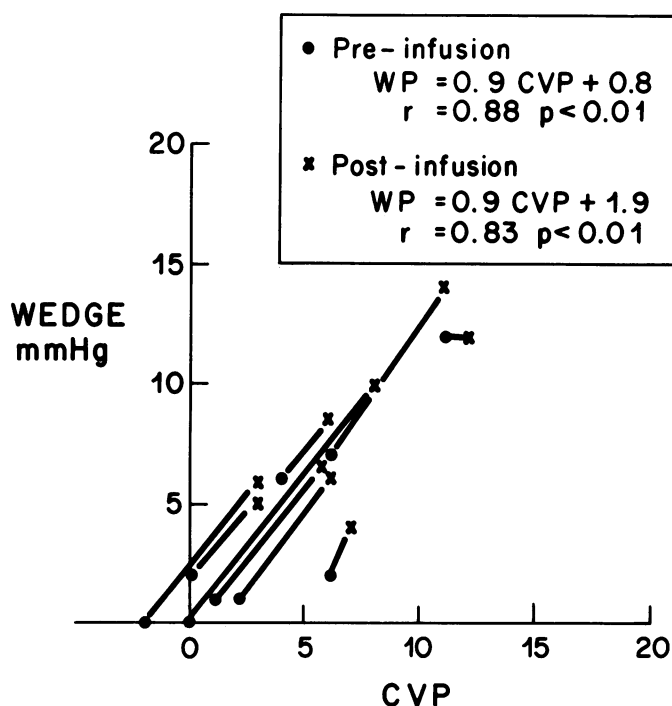


FIG. 4. 500 cc. blood or plasma was infused in short period of time in a group of patients. The significant relationship between CVP and WP was maintained after infusion. Changes appeared proportional as well.

In a patient with compromised pulmonary or cardiac function, pneumonectomy has been attended by high mortality.<sup>16</sup> Use of pulmonary artery pressure at rest and after temporary pulmonary artery occlusion has been advocated to aid in the preoperative assessment of risk.<sup>20</sup> Since myocardial failure is a prominent cause of death in such patients, knowledge of the wedge pressure is additionally helpful. Continuous monitoring of pulmonary artery and wedge pressure before, during and after operation may be of aid in selection, separation and therapy in this group of patients.

Finally, arterial venous O<sub>2</sub> content differences are related to cardiac output and oxygen consumption. The oxygen content of central venous blood has been widely employed to calculate this difference.<sup>4,12</sup> However, the range of oxygen saturation in superior vena caval blood samples is twice that found in the pulmonary artery in normal patients.<sup>13</sup> In serious illness we have found that central venous O<sub>2</sub> content bears no predictable relation to that found in pulmonary arterial blood, even in the same patient over a period of time. Assessment of cardiac output based on arterial to pulmonary artery O<sub>2</sub> concentration difference, though still of limited use,<sup>5</sup> is still more reliable than that obtained using central venous blood.

### Conclusion

The advent of the flow directed, pulmonary artery catheter should introduce an era in which the ability to monitor critically ill surgical patients will be enhanced, in the way forecast when central venous pressure monitoring was introduced.<sup>2</sup> Reliance upon central venous pressure measurement as an index of left ventricular filling pressures is contrary to established physiologic principles.<sup>1,18</sup> However, right and left ventricular function in most clinical situations vary proportionately so that central venous pressure monitoring can be indirectly used to judge the adequacy of blood volume in relation to ventricular performance. When normal biventricular function is disturbed, however, the lack of true physiologic relationship between right sided filling pressures and left ventricular work is uncovered so that central venous pressure measurement can be misleading. Utilization of the flow directed, pulmonary artery catheter in such circumstances provides the necessary information in a convenient way that is readily applicable to the postoperative care of critically ill surgical patients. We have described alterations in the technic initially advocated to enhance and adapt it to widespread use in surgical patients. Finally, some clinical situations in which this technic has been of great value are briefly

described. We know that as experience with the technic mounts, additional uses will be discovered.

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